3.2 Near-Facility Environmental Monitoring

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Near-facility (near-field) environmental monitoring is defined as routine monitoring near facilities that have potential to discharge, or have discharged, stored, or disposed of radioactive or hazardous contaminants. Monitoring locations are associated with nuclear facilities such as tank farms and the K Basins; inactive nuclear facilities such as N Reactor and Plutonium-Uranium Extraction Plant; and waste storage or disposal facilities such as burial grounds, cribs, ditches, ponds, tank farms, and trenches.

Much of the monitoring program consists of collecting and analyzing environmental samples and methodically surveying areas near facilities releasing effluents and waste streams. The program is also designed to evaluate acquired analytical data, determine the effectiveness of facility effluent monitoring and controls, measure the adequacy of containment at waste disposal units, and detect and monitor unusual conditions. The program implements applicable portions of DOE Orders 5400.1, 5400.5, 5484.1, and 5820.2A; 10 CFR 835 and 40 CFR 61; and WAC 246-247.

Several types of environmental media are sampled, and various radiological and nonradiological measurements are taken near Hanford Site facilities to monitor the effectiveness of effluent treatment and control practices, diffuse source emissions, and contamination control in waste management and restoration activities. These include air, surface and spring water, surface contamination, soil and vegetation, external radiation, and investigative samples (which can include wildlife). Samples are collected from known or expected effluent pathways. These pathways are generally downwind of potential or actual airborne releases and downgradient of liquid discharges.

Active and inactive waste disposal sites and the terrain surrounding them are surveyed to detect and characterize radioactive surface contamination. Routine survey locations include cribs, trenches, retention basin perimeters, pond perimeters, ditch banks, solid waste disposal sites (e.g., burial grounds), unplanned release sites, tank farm perimeters, stabilized waste disposal sites, roads, and firebreaks in and around the site operational areas.

Sampling and analysis information and analytical results for 1998 are summarized below. Additional data may be found in *Hanford Site Near-Facility Environmental Monitoring Data Report for Calendar Year 1998* (PNNL-12088, APP. 2). The routine activities of near-facility monitoring in 1998 are summarized in Table 3.2.1, which shows the type, quantity, and general location of samples collected.

3.2.1 Air Monitoring

Monitoring for radioactivity in air near Hanford Site facilities used a network of continuously operating samplers at 71 locations (Table 3.2.2) (sampling locations illustrated in PNNL-12088, APP. 2). Air samplers were located primarily at or within approximately 500 m [1,500 ft] of sites and/or facilities having the potential for, or history of, environmental releases, with an emphasis on the prevailing

Table 3.2.1. Near-Facility Routine Environmental Monitoring Samples and Locations, 1998

Sample Type	Number of Sample Locations	Operational Area								
		100-B,C	100-D,DR	100-K	100-F	100-N	ERDF[a]	200/600	300/400	TWRS[b]
Air	71	3	6	4	2	4	3	43[c]	6[d]	0
Water	12	0	0	0	0	10	0	2	0	0
External radiation	139	4	5	11	0	22	3	63	21	10
Soil	78	0	0	0	0	7	1	55	15	0
Vegetation	72	0	0	0	0	9	0	48	15	0

(a) Environmental Restoration Disposal Facility.
(b) Tank Waste Remediation System.
(c) Includes one station located at the Wye Barricade, 21 in the 200-East Area, and 21 in the 200-West Area.
(d) At the 300-FF-1 Operable Unit north of the 300 Area.

downwind direction. To avoid duplication of sampling, air data for the 300 and 400 Areas, some onsite remediation projects, and some offsite distant locations were obtained from existing Pacific Northwest National Laboratory air samplers.

Samples were collected according to a schedule established before the monitoring year. Airborne particles were sampled at each of these stations by drawing air through a glass-fiber filter. The filters were collected biweekly, field surveyed for gross radioactivity, held for at least 7 d, and then analyzed for gross alpha and beta activity. The 7-d holding period was necessary to allow for the decay of naturally occurring radionuclides that would otherwise obscure detection of longer-lived radionuclides associated with emissions from nuclear facilities. The gross radioactivity measurements were used to indicate changes in trends in the near-facility environment.

For most specific radionuclide analyses, the amount of radioactive material collected on a single filter during a 2-wk sampling period was too small to be measured accurately. The accuracy of the sample analysis was increased by compositing the samples into biannual samples for each location.

Figure 3.2.1 shows average values for 1998 and the preceding 5 yr for selected radionuclides in the 100 and 200 Areas compared to the DOE derived concentration guides and background air activity measured in distant communities. The DOE derived concentration guides (DOE Order 5400.5) are reference values that are used as indexes of performance. The data indicate a large degree of variability. Air samples collected from areas located at or directly adjacent to Hanford Site facilities had higher activities than did those samples collected farther away. In general, analytical results in all areas were at or near Hanford Site background activities for most radionuclides and much less than the DOE derived concentration guides. The data also show that activities of certain radionuclides were higher within different operational areas. For the radionuclides of interest, operational area and project-specific annual averages for 1998, with their corresponding maximum values, are shown in Table 3.2.3. The remedial action, interim safe storage, and surveillance and maintenance/transition projects listed below are described in more detail in Section 2.3.12, "Environmental Restoration Project."

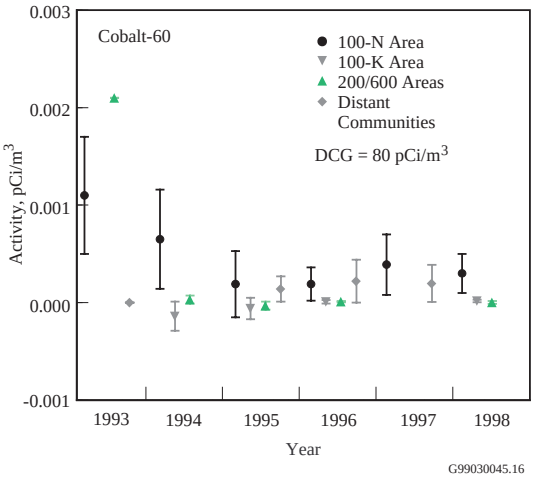
The 1998 analytical results for the 100-B,C and D remedial action projects indicated that activities

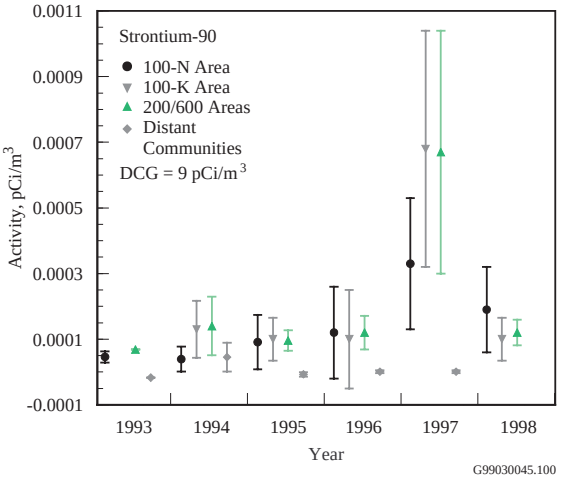
Table 3.2.2. Near-Facility Air Sampling Locations and Analyses, 1998

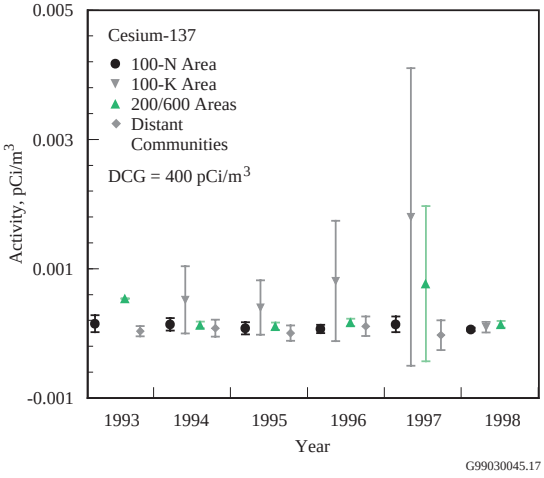
Site	Number of Samplers	EDP Code[a]	Analyses	
			Biweekly	Composite
100-B,C remedial action project	3	N464, N465, N466	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
100-D remedial action project	4	N467, N468, N469, N470	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
100-DR interim safe storage project	2	N492, N493	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
100-F interim safe storage project	2	N494, N495	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
100-K spent nuclear fuels	4	N401, N402, N403, N404	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso, Pu-241, Am-241
100-N surveillance and maintenance/transition	4	N102, N103, N105, N106	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
200-East Area	19	N019, N158, N498, N499, N950, N957, N967, N968, N969, N970, N972, N973, N976, N977, N978, N984, N985, N998, N999	Gross alpha, gross beta	GEA,[b] Sr-90, Pu-iso,[c] U-iso[d]
Canister Storage Building, 200-East Area	2	N480, N481	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso, Pu-241, Am-241
200-West Area	21	N155, N161, N165, N168, N200, N304, N433, N441, N442, N449, N456, N457, N956, N963, N964, N965, N966, N974, N975, N987, N994	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
300-FF-1 remedial action project	6	N130, N485, N486, N487, N488, N489	Gross alpha, gross beta	GEA, U-iso
600 Area	1	N981	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
Environmental Restoration Disposal Facility	3	N482, N483, N484	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso

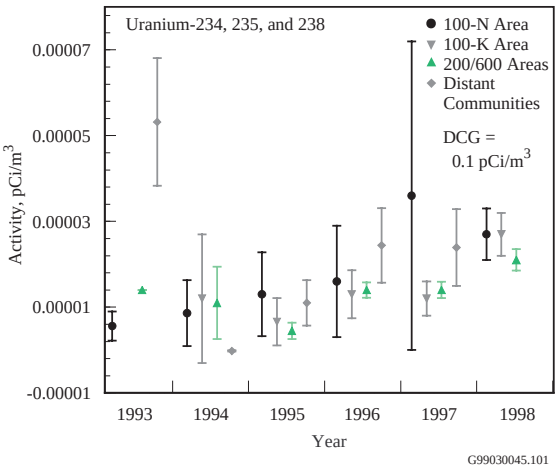
(a) EDP Code = sampler location code. See PNNL-12088, APP. 2.
(b) GEA = gamma energy analysis.
(c) Isotopic plutonium-238 and -239,240.
(d) Isotopic uranium-234, -235, and -238.

were only slightly greater than levels measured off the site. At the 100-B,C project, ambient air monitoring locations included one upwind Pacific Northwest National Laboratory sampler at the Yakima Barricade and three project-specific downwind samplers. At the 100-D project, ambient air monitoring locations included four project-specific samplers, one upwind and three downwind. Consistently detectable radionuclides were cesium-137 and uranium-234, -235, and -238. Occasionally detectable radionuclides were strontium-90 and plutonium-239,240.









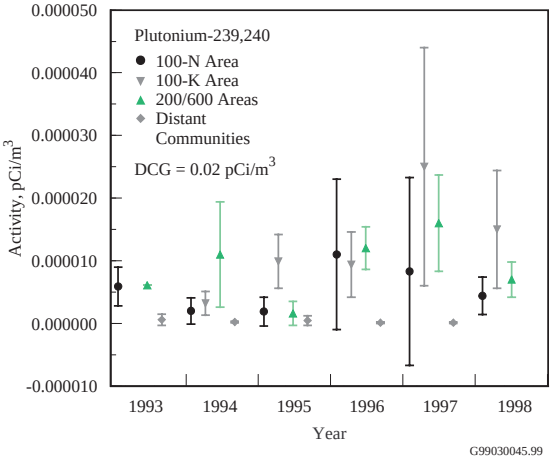


Figure 3.2.1. Average Activities (±2 standard error of the mean) of Selected Radionuclides in Near-Facility Air Samples Compared to Those in Distant Communities, 1993 Through 1998. As a result of figure scale, some uncertainties (error bars) are concealed by point symbol. Cobalt-60 was not detected in the 100-K Area in 1998. DCG = Derived concentration guide (DOE Order 5400.5).

Table 3.2.3. Annual Average and Maximum Activities (aCi/m³) of Radionuclides in Near-Facility Air Samples, 1998

Cobalt-60

Site	Average[a]	Maximum[b]	EDP Code[c]
100-B,C	23 ± 32	79 ± 77	N464
100-D	24 ± 18	72 ± 55	N467
100-F/DR	-44 ± 110	160 ± 500	N495
100-K	1.7 ± 12	44 ± 62	N402
100-N	280 ± 230	1,000 ± 140	N105
200-East	-8.3 ± 31	270 ± 430	N499
200-West	11 ± 10	58 ± 81	N441
300-FF-1	9.9 ± 19	76 ± 550	N489
ERDF[d]	-4.9 ± 29	40 ± 56	N484
Distant community[e]	196 ± 190	640 ± 490	
DCG[f]		80,000,000	

Strontium-90

Site	Average[a]	Maximum[b]	EDP Code[c]
100-B,C	87 ± 140	370 ± 210	N466
100-D	92 ± 110	400 ± 120	N467
100-F/DR	290 ± 310	890 ± 590	N495
100-K	100 ± 66	220 ± 99	N403
100-N	190 ± 130	480 ± 110	N105
200-East	190 ± 67	960 ± 190	N984
200-West	62 ± 33	140 ± 140	N161
300-FF-1	130 ± 200	230 ± 160	N130
ERDF[d]	150 ± 94	350 ± 110	N484
Distant community[e]	-5.28 ± 4.3	-3.1 ± 16	
DCG[f]		9,000,000	

Cesium-137

Site	Average[a]	Maximum[b]	EDP Code[c]
100-B,C	160 ± 89	370 ± 110	N464
100-D	82 ± 37	160 ± 80	N467
100-F/DR	-38 ± 160	170 ± 290	N494
100-K	97 ± 81	360 ± 130	N401
100-N	61 ± 25	100 ± 85	N102
200-East	190 ± 93	1,500 ± 610	N499
200-West	110 ± 40	33 ± 63	N965
300-FF-1	58 ± 130	480 ± 120	N130
ERDF[d]	220 ± 320	1,000 ± 200	N483
Distant community[e]	-27 ± 230	370 ± 700	
DCG[f]		400,000,000	

Uranium-234

Site	Average[a]	Maximum[b]	EDP Code[c]
100-B,C	26 ± 4.6	31 ± 13	N465
100-D	21 ± 2.9	26 ± 8.8	N470
100-F/DR	41 ± 7.4	52 ± 33	N494
100-K	38 ± 12	70 ± 13	N401
100-N	35 ± 11	55 ± 13	N106
200-East	27 ± 4.5	86 ± 48	N498
200-West	30 ± 7.1	12 ± 6.2	N441
300-FF-1	90 ± 29	190 ± 63	N487
ERDF[d]	32 ± 8.0	47 ± 13	N482
Distant community[e]	21 ± 0.70	21 ± 5.6	
DCG[f]		90,000	

Uranium-235

Site	Average[a]	Maximum[b]	EDP Code[c]
100-B,C	9.1 ± 4.6	18 ± 6.8	N464
100-D	9.9 ± 4.7	22 ± 10	N467
100-F/DR	23 ± 9.8	36 ± 35	N495
100-K	24 ± 8.0	41 ± 11	N401
100-N	15 ± 8.3	35 ± 15	N103
200-East	14 ± 3.5	53 ± 28	N480
200-West	15 ± 3.7	1.6 ± 5.6	N987
300-FF-1	24 ± 6.4	39 ± 33	N488
ERDF[d]	8.0 ± 1.9	11 ± 8.3	N483
Distant community[e]	0.15 ± 0.34	0.32 ± 1.1	
DCG[f]		100,000	

Uranium-238

Site	Average[a]	Maximum[b]	EDP Code[c]
100-B,C	22 ± 7.5	36 ± 12	N465
100-D	17 ± 4.4	23 ± 8.3	N468
100-F/DR	59 ± 19	89 ± 50	N495
100-K	20 ± 4.5	31 ± 8.4	N403
100-N	30 ± 13	58 ± 14	N106
200-East	22 ± 5.0	100 ± 58	N498
200-West	22 ± 8.0	2.7 ± 3.2	N956
300-FF-1	78 ± 29	180 ± 59	N487
ERDF[d]	30 ± 10	46 ± 13	N482
Distant community[e]	17 ± 0.10	17 ± 51	
DCG[f]		100,000	

Two samplers for each of the 100-F and DR interim safe storage projects began operating in August and November 1998, respectively. The analytical results from both projects indicated that the activities were only slightly greater than levels measured off the site. The only consistently detectable radionuclides were uranium-234, -235, and -238. Plutonium-239,240 was occasionally detectable.

The airborne contaminant levels in the 100-K Area were greater than levels measured off the site.

Table 3.2.3. (contd)

Plutonium-238

Site	Average[a]	Maximum[b]	EDP Code[c]
100-B,C	-3.4 ± 11	6.4 ± 7.0	N466
100-D	1.8 ± 2.6	7.4 ± 5.6	N467
100-F/DR	11 ± 6.7	24 ± 24	N493
100-K	-0.18 ± 6.0	13 ± 27	N401
100-N	-0.039 ± 3.1	9.6 ± 8.9	N103
200-East	3.6 ± 3.5	38 ± 61	N498
200-West	0.3 ± 1.3	9.8 ± 11	N956
300-FF-1	1.6 ± 5.9	4.5 ± 6.7	N130
ERDF[d]	5.8 ± 6.2	20 ± 14	N484
Distant community[e]	0.005 ± 0.16	0.09 ± 0.64	
DCG[f]		30,000	

Plutonium-239,240

Site	Average[a]	Maximum[b]	EDP Code[c]
100-B,C	8.6 ± 8.3	29 ± 9.6	N466
100-D	4.5 ± 3.6	16 ± 8.8	N468
100-F/DR	22 ± 10	42 ± 31	N495
100-K	15 ± 9.4	38 ± 21	N401
100-N	4.4 ± 3.0	13 ± 6.5	N105
200-East	4.8 ± 2.2	32 ± 30	N480
200-West	9.6 ± 4.8	0.76 ± 1.5	N456
300-FF-1	-0.02 ± 1.5	0.71 ± 7.1	N130
ERDF[d]	11 ± 8.9	30 ± 10	N484
Distant community[e]	-0.22 ± 0.16	-0.15 ± 0.43	
DCG[f]		20,000	

Plutonium-241

Site	Average[a]	Maximum[b]	EDP Code[c]
100-K	-19 ± 790	1,200 ± 1,400	N404
200-East	-3,000 ± 1,400	-2,300 ± -2,000	N481
200-West	1,100 ± 220	900 ± 450	N165
Distant community[e]		Not reported[g]	
DCG[f]		1,000,000	

Americium-241

Site	Average[a]	Maximum[b]	EDP Code[c]
100-K	28 ± 5.2	41 ± 16	N401
200-East	97 ± 46	120 ± 67	N481
200-West	27 ± 3.7	23 ± 17	N964
Distant community[e]		Not reported[g]	
DCG[f]		20,000	

(a) ±2 standard error of the mean.
(b) ± overall analytical error.
(c) Sampler location code. See PNNL-12088, APP. 2.
(d) ERDF = Environmental Restoration Disposal Facility.
(e) PNNL-11795.
(f) DOE derived concentration guide.
(g) Reported value less than its overall error, or less than zero, or no peak detected.

Facility emissions in the 100-K Area decreased substantially in 1996, and subsequent radionuclide activities seen in the ambient air samples have been near detection limits. Consistently detectable radionuclides were uranium-234, -235, and -238. Occasionally detectable radionuclides were strontium-90 and cesium-137.

Analytical results from ambient air samples taken from the 100-N Area were slightly greater than levels measured off the site. Consistently detectable radionuclides were cobalt-60 and uranium-234, -235, and -238. Occasionally detectable radionuclides were strontium-90, cesium-137, and plutonium-239,240.

Radionuclide levels measured in the 200 Areas were greater than those measured off the site. Consistently detectable radionuclides were cesium-137 and uranium-234, -235, and -238. Occasionally detectable radionuclides were strontium-90 and plutonium-239,240.

Through November 1998, samplers at the 300-FF-1 Operable Unit remedial action project

included one near-facility monitoring upwind location at the nearby 300 Area Treated Effluent Disposal Facility; two Pacific Northwest National Laboratory upwind monitors in the 300 Area (stations #14 "300 Trench" and #15 "300 NE;" see Section 4.1, "Air Surveillance"); and three downwind, project-specific air monitors. Beginning in December 1998, two additional downwind, project-specific samplers were deployed to support expanded remediation activities. The analytical results indicated that radionuclide activities in air samples collected at this site were much less than the DOE derived concentration guides and only slightly greater than levels measured off the site. The only consistently detectable radionuclides were uranium-234, -235, and -238. Cesium-137 was occasionally detectable.

The air sampling network at the Environmental Restoration Disposal Facility used two existing Hanford Site monitors for upwind monitoring and three additional air monitors that provided downwind coverage. The 1998 analytical results indicated that the activities were only slightly greater than levels measured off the site. The only consistently detectable radionuclides were uranium-234, -235, and -238. Occasionally detectable radionuclides were strontium-90, cesium-137, and plutonium-239,240.

A complete listing of the 1998 near-facility ambient air monitoring results can be found in PNNL-12088, APP. 2. Results for selected Pacific Northwest National Laboratory air samples are also reported in PNNL-12088, APP. 2, as well as in Section 4.1, "Air Surveillance."

3.2.2 Surface-Water Disposal Units and 100-N Area Riverbank Springs Monitoring

Two surface-water disposal units in the 200-East Area that received potentially radiologically contaminated effluents were sampled during 1998: the 200-East Area Powerhouse Ditch and the 216-B-3C Expansion Pond. Both radiological samples and nonradiological measurements (pH, nitrates) were obtained. In June 1998, the 200-East Area Powerhouse was deactivated and sampling for liquids was discontinued. In 1997, the effluent stream to the 216-B-3C Expansion Pond was rerouted to the 200 Areas Treated Effluent Disposal Facility and only aquatic vegetation and sediment samples were collected in 1998.

Other water samples were taken at riverbank springs in the 100-N Area. The sampling methods are discussed in detail in WMNW-CM-004. Samples were also collected from a small discharge pond in the 400 Area by Pacific Northwest National Laboratory. Analytical results for the 400 Area samples are reported in Section 4.2, "Surface Water and Sediment Surveillance," and are not discussed here.

All radiological analyses were performed onsite at the Waste Sampling and Characterization Facility near the 200-West Area in 1998. Radiological analyses of 200-East Area water samples included uranium, tritium, strontium-90, plutonium-238, plutonium-239,240, and gamma-emitting radionuclides. Radiological analyses of sediment and aquatic vegetation samples were performed for uranium, strontium-90, plutonium-239,240, and gamma-emitting radionuclides. Analyses for riverbank springs water included tritium, strontium-90, and gamma-emitting radionuclides. Nonradiological analyses were performed for pH, temperature, and nitrates. Analytes of interest were selected based on their presence in effluent discharges, their importance in verifying effluent control, and compliance with applicable effluent discharge standards.

The radiological results for liquid samples from the 200-East Area surface-water disposal unit are summarized in Table 3.2.4. In all cases, radionuclide levels were less than the DOE derived concentration guides.

Table 3.2.4. Radiological Results (pCi/L) for Liquid Samples from a Surface-Water Disposal Unit, 200 Areas, 1998

Sample Location	No. of Samples		^{3}H[(a)]	^{90}Sr	^{137}Cs	^{238}Pu	$^{239,240}Pu$	$^{Total}U$
200-East Area	6	Mean	ND[(b)]	2.5 ± 2.1	ND	0.36 ± 0.10	ND	0.13 ± 0.05
Powerhouse Ditch		Maximum	ND	2.5 ± 2.1	ND	0.36 ± 0.10	ND	0.46 ± 0.11
		DCG[(c)]	2,000,000	1,000	3,000	40	30	500[(d)]

(a) The detection limit for tritium was between 170 and 220 pCi/L. Samples were collected quarterly.
(b) ND = Not detected.
(c) DCG = DOE derived concentration guide (DOE Order 5400.5).
(d) Using uranium-234 as the most limiting DCG.

Radiological results for aquatic vegetation and sediment samples taken from the 200-East Area surface-water disposal units are summarized in Tables 3.2.5 and 3.2.6, respectively. Although there were some levels above background in both aquatic vegetation and sediment, all results were much less than the standards cited in the *Hanford Site Radiological Control Manual* (HSRCM-1, Rev. 2).

In the past, radioactive effluent streams sent to the 1301-N and 1325-N Liquid Waste Disposal Facilities in the 100-N Area contributed to the release of radionuclides to the Columbia River through their migration with the groundwater. Radionuclides from these facilities enter the Columbia River along the riverbank region sometimes called N Springs. The amount of radionuclides entering the river at these springs is calculated based on analyses of monthly samples collected from monitoring well 199-N-46 located near the shoreline. To verify releases, conservatively high radionuclide activities in samples collected from well 199-N-46 are multiplied by the estimated groundwater discharged into the river. The groundwater flow rate at these springs was estimated using a computer model developed by Gilmore et al. (PNL-8057). The estimated groundwater flow rate used to calculate 1998 releases from the springs was 43 L/min (11 gal/min). The results of the spring samples can then be compared to the activities measured in well 199-N-46 to ensure that activities in the well reflect the highest activities of radionuclides in the groundwater. A more detailed discussion of the release calculations may be found in HNF-EP-0527-8.

Groundwater springs and/or shoreline seepage wells along the 100-N Area shoreline are sampled annually to verify that the reported radionuclide releases to the Columbia River are conservative (i.e., not underreported). In September 1998, 10 samples were collected. At the time of sample collection, 3 of the 13 shoreline wells were dry, and no samples were collected at these locations. The shoreline seepage well samples were collected using a bailer, carefully lowered into each well water column to avoid sediment suspension, and a 4-L (1-gal) sample was obtained.

In 1998, the levels of tritium and strontium-90 detected in samples from riverbank springs were highest in N Springs well Y303, which is nearest well 199-N-46. Strontium-90 exceeded the DOE derived concentration guide value at well Y303, and the highest tritium level was also measured at this location, though it was well below its derived concentration guide value. The highest cobalt-60 levels, though very low, were from a location approximately 200 m (656 ft) downriver (northeast) of well

Table 3.2.5. Radiological Results (pCi/g, dry wt.)[a] for Aquatic Vegetation Samples from Surface-Water Disposal Units, 200 Areas, 1998

Sample Location	No. of Samples	^{90}Sr	^{137}Cs	^{239,240}Pu	^{234}U	^{235}U	^{238}U
216-B-3C Expansion Pond, 200-East Area	1	0.24 ± 0.12	36.0 ± 5.8	0.35 ± 0.06	0.44 ± 0.08	0.03 ± 0.01	0.36 ± 0.07
200-East Area Powerhouse Ditch	1	0.38 ± 0.15	ND[b]	ND	0.81 ± 0.14	0.06 ± 0.02	0.72 ± 0.12

(a) ± overall analytical error.
(b) ND = Not detected.

Table 3.2.6. Radiological Results (pCi/g, dry wt.)[a] for Sediment Samples from Surface-Water Disposal Units, 200 Areas, 1998

Sample Location	No. of Samples	^{90}Sr	^{137}Cs	^{239,240}Pu	^{234}U	^{235}U	^{238}U
216-B-3C Expansion Pond, 200-East Area	1	ND[b]	0.23 ± 0.09	ND	0.006 ± 0.005	0.006 ± 0.004	ND
200-East Area Powerhouse Ditch	1	ND	ND	ND	0.01 ± 0.005	0.003 ± 0.002	0.004 ± 0.003

(a) ± overall analytical error.
(b) ND = Not detected.

199-N-46. All of the riverbank springs activities were lower than those measured in well 199-N-46. The data from riverbank springs sampling are summarized in Table 3.2.7.

Nonradiological results for water samples taken from the 200-East Area surface-water disposal unit are summarized in Table 3.2.8. The results for pH were well within the standard of 2.0 to 12.5 for liquid effluent discharges based on the limits given in the Resource Conservation and Recovery Act of 1976. The analytical results for nitrates were all less than the 45-mg/L federal and state drinking water standards for public water supplies (40 CFR 141, WAC 246-249).

3.2.3 Radiological Surveys

Radiological surveys are used to monitor and detect contamination on the Hanford Site. The main types of posted radiologically controlled areas are underground radioactive materials, contamination areas, soil contamination areas, and high contamination areas.

Table 3.2.7. Radionuclide Activities (pCi/L) in 100-N Area Riverbank Springs, 1998

Radionuclide	Facility Effluent Monitoring Well 199-N-46[a]	Shoreline Springs Maximum[b]	Shoreline Springs Average[a]	DCG[c]
Tritium	16,000 ± 5,200	1,400 ± 364	540 ± 200	2,000,000
Cobalt-60	<-6.8 ± 5.7	<5.3 ± 4.6	<0.69 ± 1.8	5,000
Strontium-90	14,000 ± 2,100	1,900 ± 228	220 ± 370	1,000

(a) ±2 standard error of the mean.
(b) ± overall analytical error.
(c) DCG = DOE derived concentration guide (DOE Order 5400.5).

Table 3.2.8. Nonradiological Results for Water Samples from a Surface-Water Disposal Unit, 200 Areas, 1998

Sample Location	No. of Samples	pH Mean	pH Maximum	pH Minimum	No. of Samples	Nitrate (NO_3), mg/L Mean	Nitrate (NO_3), mg/L Maximum
200-East Area Powerhouse Ditch	24	7.2	9.1	6.0	2	0.17	0.24

Underground radioactive material areas are posted areas that have contamination contained below the soil surface. These areas are typically "stabilized" cribs, burial grounds, covered ponds, trenches, and ditches. Barriers over the contamination sources are used to inhibit radionuclide transport to the surface environs. These areas are surveyed at least annually to document the current radiological status.

Contamination/soil contamination areas may or may not be associated with an underground radioactive material structure. A breach in the barrier of an underground radioactive materials area may result in the growth of contaminated vegetation. Insects or animals may burrow into an underground radioactive materials area and bring contamination to the surface. Vent pipes or risers from an underground structure may be a source of speck contamination. Areas of contamination not related to subsurface structures can include sites contaminated with fallout from effluent stacks and sites that are the result of unplanned releases (e.g., contaminated tumbleweeds, animal feces). All radiologically controlled areas may be susceptible to contamination migration and are surveyed at least annually to document the current radiological status (locations of radiologically controlled areas are illustrated in PNNL-12088, APP. 2).

In 1998, the Hanford Site had approximately 3,641 ha (8,999 acres) of posted outdoor contamination areas (all types) and 587 ha (1,450 acres) of posted underground radioactive materials areas not including active facilities. The number of hectares (acres) of contamination areas (all types) is approximately six times larger than the underground

radioactive materials areas. This is primarily because of the BC Cribs controlled area located south of the 200-East Area. This area was initially posted as a radiologically controlled area in 1958 because of widespread speck contamination and encompassed approximately 1,000 ha (2,500 acres). Investigative radiological surveys begun in 1996 and completed in 1998 adjacent to the BC Cribs area established that the size of the area was 3,482 ha (8,604 acres). Table 3.2.9 lists the contamination areas and underground radioactive materials areas in 1998. A global positioning system was used in 1998 to measure more accurately the extent of the radiologically controlled areas. Area measurements are entered into the Hanford Geographical Information System, a computer database maintained by Bechtel Hanford, Inc.

The number and size of radiologically controlled areas vary from year to year because of efforts to clean, stabilize, and remediate areas of known contamination. During this time, new areas of contamination are also being identified. Table 3.2.10 indicates the

Table 3.2.9. Outdoor Contamination Status, 1998

Area	Contamination Areas,[a] ha (acres)		Underground Radioactive Materials Areas,[b] ha (acres)	
100-B,C	8	(20)	39	(96)
100-D,DR	0.1	(0.2)	39	(96)
100-F	0.1	(0.2)	5	(12)
100-H	0.1	(0.2)	14	(35)
100-K	9	(22)	62	(153)
100-N	29	(73)	0.2	(0.5)
200-East[c]	62	(153)	142	(351)
200-West[c]	34	(84)	218	(539)
300	19	(47)	13	(32)
400	0	0	0	0
600[d]	3,480	(8,599)	55	(136)
Totals	3,641	(8,999)	587	(1,450)

(a) Includes areas posted as contamination/soil contamination or as radiologically controlled and areas designated both as underground radioactive material and contamination/soil contamination.

(b) Includes areas with only underground contamination. Does not include areas that had contamination/soil contamination as well as underground radioactive material.

(c) Includes tank farms.

(d) Includes BC Cribs controlled area and inactive waste disposal facilities outside the 200-East Area boundary that received waste from 200-East Area facilities (e.g., 216-A-25 [Gable Mountain Pond], 216-B-3 [B Pond]) and inactive waste disposal facilities outside the 200-West Area boundary that received waste from 200-West Area facilities (e.g., 216-S-19 [S Pond], 216-U-11 Ditch). The first cell of the Environmental Restoration Disposal Facility was added during 1997.

Table 3.2.10. Zone Status Change of Posted Contamination Areas, 1998[a]

Areas	Zone Changes[b]	Area, ha (acres)	
100	CA to URM	1.1	(2.7)
200-East	CA to URM	1.4	(3.5)
200-East	NP to RBA	2.5	(6.2)
200-West	CA to URM	2.6	(6.4)
300	CA to URM	0	0
400	CA to URM	0	0
600	CA to NP	352	(870)

(a) Changes from stabilization activities, newly discovered sites, or resurvey using a global positioning system.
(b) CA = Contamination/soil contamination area.
URM = Underground radioactive materials area.
NP = No posting.
RBA = Radiological buffer area.

changes resulting from stabilization activities during 1998. Approximately 5.1 ha (12.6 acres) were reclassified from contamination/soil contamination areas to underground radioactive materials areas. A newly identified 2.5-ha (6.2-acre) radiological buffer area was established in 1998. A radiological buffer area is described as "an intermediate area established to prevent the spread of contamination and to protect personnel from radiation exposure" (HSRCM-1, Rev. 2). Newly identified areas may have resulted from contaminant migration or an increased effort to investigate outdoor areas for radiological contamination. Vehicles equipped with radiation detection devices and an ultrasonic ranging and data system have identified areas of contamination that were previously undetected.

It was estimated that the external dose rate at 80% of the identified outdoor contamination areas was >1 mrem/h, though direct dose rate readings from isolated radioactive specks (a diameter >0.6 cm [0.25 in.]) could have been considerably higher. Contamination levels of this magnitude did not significantly add to dose rates for the public or Hanford Site workers in 1998.

3.2.4 Soil and Vegetation Sampling from Operational Areas

Soil and vegetation samples were collected on or adjacent to waste disposal units and from locations downwind and near or within the boundaries of operating facilities and remedial action activity sites. Samples were collected to evaluate long-term trends in environmental accumulation of radioactivity and to detect potential migration and deposition of facility effluents. Special samples were also collected where physical or biological transport problems were identified. Contaminant movement can occur as the result of resuspension from radioactively contaminated surface areas, absorption of radionuclides by the roots of vegetation growing on or near underground and surface-water disposal units, or waste site intrusion by animals. The sampling methods and locations used are discussed in detail in WMNW-CM-004. Radiological analyses of soil and vegetation samples included strontium-90, isotopic uranium, isotopic plutonium, and gamma-emitting radionuclides.

Seventy-eight soil samples (7 in the 100-N Area, 55 in the 200/600 Areas, 15 in the 300/400 Areas, and 1 at the Environmental Restoration Disposal Facility) and 72 vegetation samples (9 in the 100-N Area, 48 in the 200/600 Areas, and 15 in the 300/400 Areas) were collected and the data obtained from the samples are presented in PNNL-12088, APP. 2. Only those radionuclide activities above analytical detection limits are provided in this section.

The number of locations for soil and vegetation sampling in the 100-N Area environs was reduced in 1996. Analyses of the data collected at sites not associated with the retired 1301-N and 1325-N Liquid

Waste Disposal Facilities indicated decreasing trends for contaminant migration and prompted a determination that sampling at these locations was no longer needed. For these same reasons, some N Springs sample locations were also abandoned.

Each soil sample represents a composite of five plugs of soil 2.5 cm (1 in.) deep and 10 cm (4 in.) in diameter collected from each site. Each vegetation sample consists of new-growth leaf cuttings taken from the available species of interest at each sample location. Often, the vegetation sample consisted of a composite of several like members of the sampling site plant community to avoid decimation of any individual plant through overharvesting.

Early in the summer of each year, soil and vegetation samples are collected and submitted for radioanalyses. The analyses include those for radionuclides expected to be found in the areas sampled (i.e., gamma-emitting radionuclides, strontium isotopes, uranium isotopes, and/or plutonium isotopes). The results are then compared to levels found at various offsite sample locations in Yakima and in Benton and Franklin Counties. These levels are obtained from data reported from these locations by the Pacific Northwest National Laboratory (PNNL-10574, PNNL-11795) to determine the difference between contributions from site operations and remedial action activity sites and contributions from natural causes and worldwide fallout. Special sampling for selected radionuclides in soil and vegetation was conducted in Franklin County by the Pacific Northwest National Laboratory during 1998. For more detail, see Section 4.6, "Soil and Vegetation Surveillance."

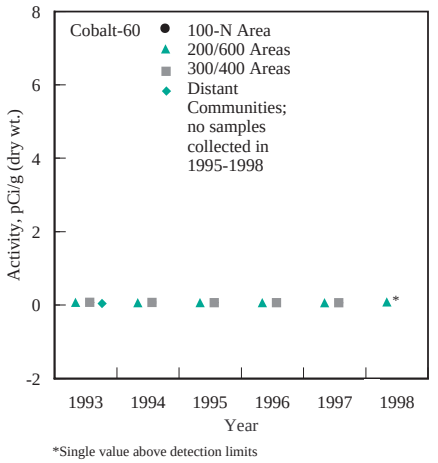
Soil sampling results are also compared to the "accessible soil" limits included in HNF-PRO-454, developed specifically for use at the Hanford Site (see PNNL-12088, APP. 2 for complete listing). These radioactive limits were established to ensure that effective dose equivalents to the public do not exceed the established limits for any reasonable scenario, such as direct exposure, inadvertent ingestion, inhalation, and ingestion of food crops, including animal products. Conservatism inherent in pathway programming ensures that the required degrees of protection are in place. These limits apply specifically to the Hanford Site with respect to onsite disposal operations, stabilization and cleanup, and decontamination and decommissioning operations.

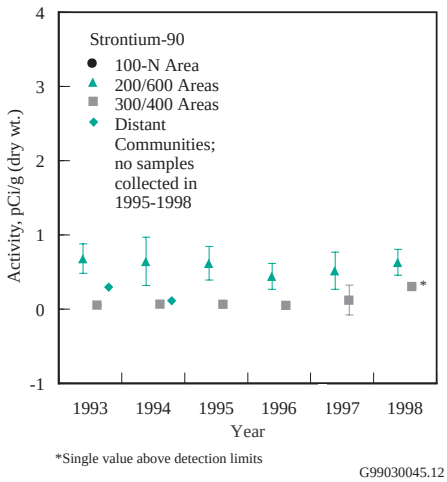
In general, activities in soil and vegetation samples collected from or adjacent to waste disposal facilities were higher than activities in samples collected farther away and were significantly higher than historical activities measured off the site. The data also show, as expected, that activities of certain radionuclides were higher within different operational areas when compared to activities measured in distant communities. Generally, the predominant radionuclides were activation and fission products in the 100-N Area, fission products in the 200 Areas, and uranium in the 300/400 Areas.

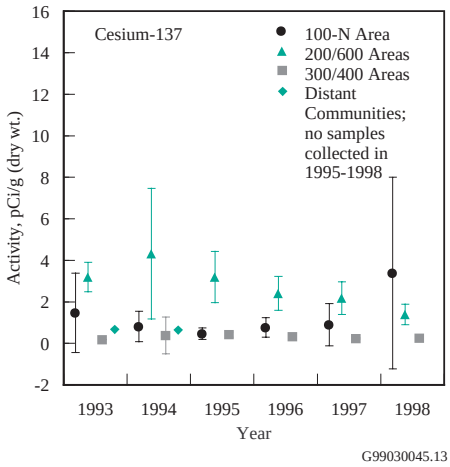
3.2.4.1 Radiological Results for Soil Samples

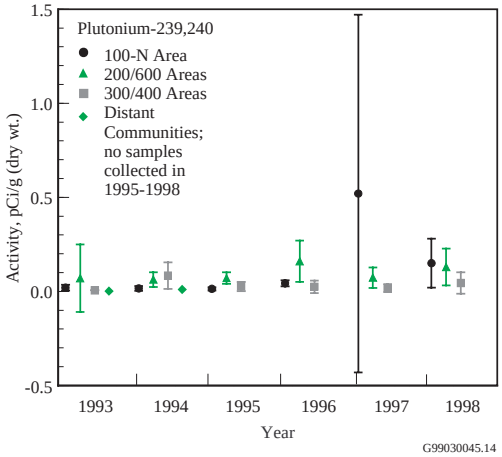
Of the radionuclide analyses performed, cobalt-60, strontium-90, cesium-137, plutonium-239,240, and uranium were consistently detectable. Activities of these radionuclides in soil samples were elevated near and within facility boundaries when compared to activities measured off the site. Figure 3.2.2 shows average soil values for 1998 and the preceding 5 yr. The activities show a large degree of variability.

Surface soil samples collected near the retired 1301-N Liquid Waste Disposal Facility contained radionuclides that were typically present in past effluent stream discharges. Generally, the samples collected near this facility exhibited relatively higher radionuclide activities than those collected at the other soil sampling locations in the 100-N Area. As in 1997, radionuclide activities from sampling site Y602, located on the eastern side of the retired 1301-N facility, exhibited slightly elevated levels of









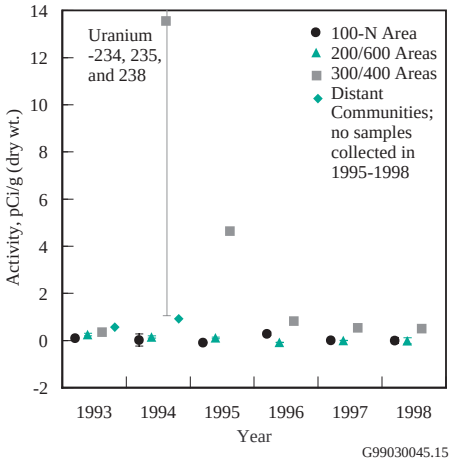


Figure 3.2.2. Average Activities (±2 standard error of the mean) of Selected Radionuclides in Near-Facility Soil Samples Compared to Those in Distant Communities, 1993 Through 1998. As a result of figure scale, some uncertainties (error bars) are concealed by point symbol. The 1994, 1995, 1996, 1997, and 1998 100 Areas data include the 100-N Area only.

cobalt-60, strontium-90, and cesium-137. It is likely that these increased levels are due to resuspension of contaminated material from the facility itself because the vegetation in the immediate vicinity of Y602 (i.e., Y702 vegetation sampling site) did not exhibit a corresponding pattern of elevated radionuclide activities. Average radionuclide activities detected in the surface soil samples near the facility from 1993 through 1998 are presented in Table 3.2.11. Generally, results were at or near historical onsite levels. However, activities of cobalt-60, strontium-90, plutonium-238, and plutonium-239,240 were noticeably elevated at a sampling location near the retired 1301-N facility. Additionally, contamination levels for these radionuclides were greater than those previously measured off the site and in the 200 and 300/400 Areas. The cobalt-60, strontium-90, and plutonium-239,240 activities in the 100-N Area soils resulted from past discharges to waste disposal structures, primarily the 1301-N facility.

Average radionuclide activities detected in all of the surface soil samples collected in the 100-N Area from 1993 through 1998 are presented in Table 3.2.12. The 1998 maximum, average, offsite average activities, and accessible soil limits are compared in Table 3.2.13. Offsite averages for isotopic uranium, strontium-90, and cesium-137 are from PNNL-11795 and offsite values for plutonium-239,240 are contained in PNL-10574. Complete listings of radionuclide activities and sample location maps are provided in PNNL-12088, APP. 2.

Soil samples from 55 of 111 sample locations in the 200/600 Areas were collected in 1998. A follow-up sample location (D146) was again included this year from the southern end of the Environmental Restoration Disposal Facility and will now be sampled on an annual basis. The 1998 maximum, average, offsite average, and accessible soil limits are compared in Table 3.2.14. Complete listings of radionuclide activities and sample location maps are provided in PNNL-12088, APP. 2.

Analytical results from soil samples taken from the 200/600 Areas demonstrated a general downward trend for most radionuclides. However, the cesium-137 results in the 200 Areas were greater than previous offsite measurements and values obtained from the 100 and 300/400 Areas.

Soil samples from 15 sample locations in the 300/400 Areas were collected in 1998; 14 from the

Table 3.2.11. Average Radionuclide Activities (pCi/g)[(a)] Detected in Surface Soil Samples Near the 1301-N Liquid Waste Disposal Facility, 1993 Through 1998

Year	^{60}Co	^{90}Sr	^{137}Cs	^{239,240}Pu
1993	9.8 ± 10.9	0.09 ± 1.3	6.2 ± 10.2	0.069 ± 0.086
1994	3.7 ± 4.8	0.33 ± 0.34	1.5 ± 1.5	0.028 ± 0.030
1995	2.1 ± 2.2	0.15 ± 0.17	0.77 ± 0.53	0.010 ± 0.013
1996	2.5 ± 1.5	0.23 ± 0.11	0.98 ± 0.57	0.048 ± 0.026
1997	4.3 ± 5.2	5.8 ± 10.8	1.5 ± 1.5	0.98 ± 1.79
1998	8.5 ± 14.4	1.6 ± 1.2	5.2 ± 7.4	0.19 ± 0.19

(a) ±2 standard error of the mean.

Table 3.2.12. Average Radionuclide Activities (pCi/g)[a] Detected in 100-N Area Surface Soil Samples, 1993 Through 1998

Year	^{60}Co	^{90}Sr	^{137}Cs	^{239,240}Pu
1993	0.030 ± 0.016	0.12 ± 0.06	0.16 ± 0.08	0.0034 ± 0.0019
1994	1.6 ± 2.1	0.19 ± 0.15	0.81 ± 0.65	0.016 ± 0.013
1995	0.94 ± 0.98	0.13 ± 0.07	0.51 ± 0.24	0.014 ± 0.009
1996	1.5 ± 1.1	0.20 ± 0.08	0.077 ± 0.042	0.043 ± 0.016
1997	2.5 ± 3.0	3.9 ± 7.2	0.89 ± 0.90	0.91 ± 1.79
1998	4.9 ± 8.4	1.2 ± 1.2	3.1 ± 4.4	0.15 ± 0.14

(a) ±2 standard error of the mean.

Table 3.2.13. Activities of Selected Radionuclides in 100-N Area Soils, 1998 (pCi/g)

	^{60}Co	^{90}Sr	^{137}Cs	^{234}U	^{235}U	^{238}U	^{239,240}Pu
Sampling locations[a]	Site Y602	Site Y604	Site Y604	Site Y602	Site Y602	Site Y602	Site Y605
Maximum[b]	30 ± 2.3	4.0 ± 0.6	16 ± 2.2	0.39 ± 0.07	0.047 ± 0.017	0.22 ± 0.04	0.42 ± 0.05
Average[c]	4.9 ± 7.7	1.2 ± 1.1	3.1 ± 4.1	0.21 ± 0.06	0.033 ± 0.007	0.17 ± 0.03	0.15 ± 0.13
Offsite average[c,d]	NR[e]	0.062 ± 0.052	0.30 ± 0.30	0.24 ± 0.09	0.11 ± 0.04	0.25 ± 0.10	0.011 ± 0.001
Accessible soil activity limits (HNF-PRO-454)[f]	7.1	2,800	30	630	170	370	190

(a) See PNNL-12088, APP. 2.
(b) ± counting error.
(c) ±2 standard error of the mean.
(d) PNNL-10574 and PNNL-11795.
(e) NR = Not reported.
(f) Hanford soils that are not behind security fences.

300 Area and 1 from the 400 Area. The 1998 maximum, average, offsite average activities, and accessible soil limits are compared in Table 3.2.15. Complete listings of radionuclide activities and sample location maps are provided in PNNL-12088, APP. 2.

Analytical results from soil samples taken from the 300/400 Areas were compared to results for other operational areas and to those measured off the site. Uranium levels in the 300/400 Areas were higher than those measured from the 100 and 200 Areas. Cobalt-60 and cesium-137 values were slightly higher than those previously measured off the site. Uranium was expected in these samples because it was used during past fuel fabrication operations in the 300 Area.

In 1998, a single soil sample was collected from the Environmental Restoration Disposal Facility

Table 3.2.14. Activities of Selected Radionuclides in 200/600 Areas Soils, 1998 (pCi/g)

	^{60}Co	^{90}Sr	^{137}Cs	^{234}U	^{235}U	^{238}U	^{239,240}Pu
Sampling locations[a]	Site D050	Site D064	Site D034	Site D068	Site D068	Site D068	Site D008
Maximum[b]	0.019 ± 0.006[c]	1.5 ± 0.3	10 ± 1.4	0.29 ± 0.06	0.044 ± 0.015	0.29 ± 0.06	1.4 ± 0.1
Average[d]	--	0.50 ± 0.14	1.1 ± 0.4	0.19 ± 0.01	0.021 ± 0.002	0.19 ± 0.01	0.13 ± 0.01
Offsite average[d,e]	NR[f]	0.062 ± 0.052	0.30 ± 0.30	0.24 ± 0.09	0.11 ± 0.04	0.25 ± 0.10	0.011 ± 0.001
Accessible soil activity limits (HNF-PRO-454)[g]	7.1	2,800	30	630	170	370	190

(a) See PNNL-12088, APP. 2.
(b) ± counting error.
(c) Single value above detection limits.
(d) ±2 standard error of the mean.
(e) PNNL-10574 and PNNL-11795.
(f) NR = Not reported.
(g) Hanford soils that are not behind security fences.

Table 3.2.15. Activities of Selected Radionuclides in 300/400 Areas Soils, 1998 (pCi/g)

	^{60}Co	^{90}Sr	^{137}Cs	^{234}U	^{235}U	^{238}U	^{239,240}Pu
Sampling locations[a]	--	Site D127	Site D127	Site D119	Site D119	Site D119	Site D119
Maximum[b]	ND[c]	0.24 ± 0.12[d]	0.58 ± 0.08	7.9 ± 1.3	0.49 ± 0.10	7.9 ± 1.3	0.23 ± 0.05
Average[e]	ND	--	0.086 ± 0.075	0.85 ± 0.98	0.065 ± 0.060	0.82 ± 0.98	0.045 ± 0.057
Offsite average[e,f]	NR[g]	0.062 ± 0.052	0.30 ± 0.30	0.24 ± 0.09	0.11 ± 0.04	0.25 ± 0.10	0.011 ± 0.001
Accessible soil activity limits (HNF-PRO-454)[h]	7.1	2,800	30	630	170	370	190

(a) See PNNL-12088, APP. 2.
(b) ± counting error.
(c) ND = Not detected.
(d) Single value above detection limits.
(e) ±2 standard error of the mean.
(f) PNNL-10574 and PNNL-11795.
(g) NR = Not reported.
(h) Hanford soils that are not behind security fences.

(location D146) to determine the effectiveness of contamination controls. The sample collected from this facility in 1997 represented the initial (baseline) sample, with the 1998 sample to be used for comparison. The 1998 data are reported in PNNL-12088, APP. 2.

3.2.4.2 Radiological Results for Vegetation Samples

Of the radionuclide analyses performed, cobalt-60, strontium-90, cesium-137, plutonium-239,240, and uranium were consistently detectable. Activities of these radionuclides in vegetation were elevated near and within facility boundaries compared to the activities measured off the site. Figure 3.2.3 shows average vegetation values for 1998 and the preceding 5 yr. The activities show a large degree of variability.

Average radionuclide activities detected in the vegetation samples near the retired 1301-N Liquid Waste Disposal Facility from 1993 through 1998 are presented in Table 3.2.16. The contaminants near the 1301-N facility were at or near historic levels. Average radionuclide activities detected in all of the vegetation samples collected in the 100-N Area from 1993 through 1998 are presented in Table 3.2.17.

Vegetation samples collected along the 100-N Area shoreline (N Springs) contain radionuclides that were not completely retained in the soil columns beneath the retired 1301-N and 1325-N Liquid Waste Disposal Facilities. Biotransport, via root uptake of cobalt-60, strontium-90, and cesium-137, was evident in the reed canary grass samples collected from this area. Most notable were the average levels of strontium-90 and cesium-137, which exhibited activities that were orders of magnitude higher than the offsite averages. Average radionuclide activities detected in the vegetation samples collected along N Springs in 1998 and during the previous 5 yr are presented in Table 3.2.18. The 1998 maximum, average, and offsite average are compared in Table 3.2.19. Complete listings of radionuclide activities and sample location maps are provided in PNNL-12088, APP. 2. Analytical results from vegetation samples collected from the 100-N Area in 1998 were within the ranges observed in previous years. The values observed for strontium-90 in samples collected near N Springs were typically higher than those seen at other locations in the 100-N Area.

Generally, 1998 radionuclide levels in 100-N Area vegetation were greater than those previously measured off the site; levels for cobalt-60, strontium-90, and cesium-137 were higher compared to the activities measured in the 200 and 300/400 Areas.

In 1998, 41 vegetation samples were collected from the 200/600 Areas. The 1998 maximum, average, and offsite average are compared in Table 3.2.20. Complete listings of radionuclide activities and sample location maps are provided in PNNL-12088, APP. 2.

Analytical results from vegetation samples taken in 1998 from the 200/600 Areas were generally comparable to those observed in previous years. Radionuclide levels for strontium-90, cesium-137, and plutonium-239,240 were greater than those measured off the site previously and were higher for cesium-137 and plutonium-239,240 compared to the 100 and 300/400 Areas.

This was the seventh year of sampling from locations established to more directly monitor facilities and active/inactive waste sites in the 300 and 400 Areas. The 1998 maximum, average, offsite average, and accessible soil limits for 300/400 Areas samples are compared in Table 3.2.21. Complete listings of radionuclide activities and sample location maps are provided in PNNL-12088, APP. 2.

Generally, the levels of most radionuclides measured in the 300 Area were greater than those measured off the site, and uranium levels were higher than measured in the 100 and 200 Areas. The higher

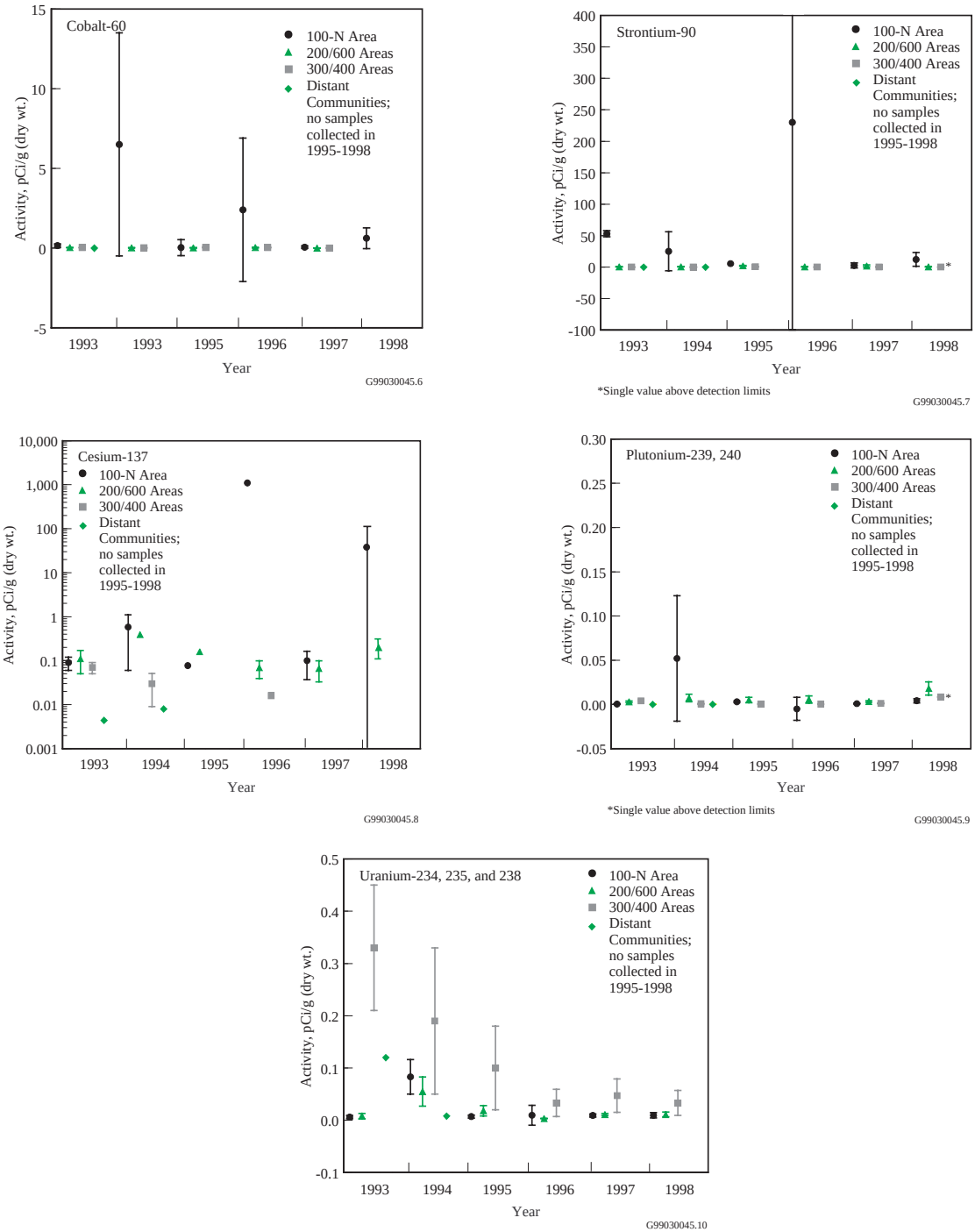


Figure 3.2.3. Average Activities (±2 standard error of the mean) of Selected Radionuclides in Near-Facility Vegetation Samples Compared to Those in Distant Communities, 1993 Through 1998. As a result of figure scale, some uncertainties (error bars) are concealed by point symbol. The 1994, 1995, 1996, 1997, and 1998 100 Areas data include the 100-N Area only. The 1997 cesium-137 data point for the 300/400 Areas is less than zero and cannot be plotted on a log scale.

Table 3.2.16. Average Radionuclide Activities (pCi/g)[a] Detected in Vegetation Samples Collected Near the 1301-N Liquid Waste Disposal Facility, 1993 Through 1998

Year	^{60}Co	^{90}Sr	^{137}Cs	^{239,240}Pu
1993	0.22 ± 0.21	0.057 ± 0.008	0.22 ± 0.09	0.00041 ± 0.00016
1994	24.8 ± 31.6	4.8 ± 6.9	1.8 ± 1.8	0.20 ± 0.27
1995	0.054 ± 0.10	0.064 ± 0.019	0.12 ± 0.14	0.008 ± 0.003
1996	6.1 ± 11.9	575 ± 1,150	2,750 ± 5,500	-0.013 ± 0.38[b]
1997	0.42[c]	0.49[c]	0.14 ± 0.06	ND[d]
1998	0.54 ± 0.93	13.6 ± 26.4	50.1 ± 99.8	0.0071[c]

(a) ±2 standard error of the mean.
(b) Negative value indicates results at or below background levels of radioactivity.
(c) Single value above detection limit.
(d) ND = Not detected.

Table 3.2.17. Average Radionuclide Activities (pCi/g)[a] Detected in 100-N Area Vegetation Samples, 1993 to 1998

Year	^{60}Co	^{90}Sr	^{137}Cs	^{239,240}Pu
1993	0.10 ± 0.09	0.036 ± 0.027	0.066 ± 0.033	0.00033 ± 0.00033
1994	6.5 ± 8.5	25 ± 33	0.58 ± 0.52	0.053 ± 0.071
1995	0.03 ± 0.05	5.4 ± 4.8	0.081 ± 0.044	0.0033 ± 0.0016
1996	2.4 ± 4.5	230 ± 430	1,100 ± 2,000	-0.0051 ± 0.013[b]
1997	0.42 ± 0.05	3.6 ± 5.3	0.16 ± 0.008	ND[c]
1998	0.62 ± 0.73	11.7 ± 11.1	37.6 ± 74.9	0.0042 ± 0.0029

(a) ±2 standard error of the mean.
(b) Negative value indicates results at or below background levels of radioactivity.
(c) ND = Not detected.

uranium levels were expected because it was released during past fuel fabrication operations in the 300 Area. The levels recorded for all other radionuclides in the 400 Area were at or slightly higher than those measured off the site in previous years.

Table 3.2.18. Average Radionuclide Activities (pCi/g)[a] Detected in N Springs Vegetation Samples, 1993 to 1998

Year	^{60}Co	^{90}Sr	^{137}Cs	^{239,240}Pu
1993	0.45 ± 0.50	258 ± 208	0.20 ± 0.12	-0.00085 ± 0.00071[b]
1994	0.14 ± 0.10	60 ± 81	0.15 ± 0.14	0.002 ± 0.001
1995	0.014 ± 0.045	13.4 ± 10.2	0.094 ± 0.059	0.0028 ± 0.0008
1996	0.01 ± 0.01	2.4 ± 4.2	0.038 ± 0.010	-0.0015 ± 0.002
1997	ND[c]	6.2 ± 9.9	0.18 ± 0.17	ND
1998	0.068[d]	21.0 ± 19.0	ND	0.0028[d]

(a) ±2 standard error of the mean.
(b) Negative value indicates results at or below background levels of radioactivity.
(c) ND = Not detected.
(d) Single value above detection limit.

Table 3.2.19. Activities of Selected Radionuclides in 100-N Areas Vegetation, 1998 (pCi/g)

	^{60}Co	^{90}Sr	^{137}Cs	^{234}U	^{235}U	^{238}U	^{239,240}Pu
Sampling locations[a]	Site Y711	Sites Y704 and Y724	Site Y704	Site Y719	Site Y702	Site Y719	Site Y702
Maximum[b]	1.9 ± 0.2	40 ± 4.8	150 ± 20	0.033 ± 0.009	0.010 ± 0.005	0.024 ± 0.007	0.0071 ± 0.0044
Average[c]	0.62 ± 0.65	12 ± 6	38 ± 65	0.014 ± 0.006	0.0055 ± 0.0022	0.0087 ± 0.0044	0.0042 ± 0.0023
Offsite averages[c,d]	NR[e]	0.025 ± 0.012	0.0072 ± 0.0083	0.014 ± 0.006	ND[f]	0.013 ± 0.004	0.00018 ± 0.00013

(a) See PNNL-12088, APP. 2.
(b) ± counting error.
(c) ±2 standard error of the mean.
(d) PNNL-10574 and PNNL-11795.
(e) NR = Not reported.
(f) ND = Not detected.

3.2.5 External Radiation

External radiation fields were monitored near facilities and waste handling, storage, and disposal sites to measure, assess, and control the impacts of operations. Thermoluminescent dosimeters are used at numerous fixed locations to gather dose rate information over longer periods of time. Thermoluminescent dosimeter results can be used individually or averaged to determine dose rates in a given area for a particular sampling period. A summary of the 1998 thermoluminescent dosimeter results can be found in Table 3.2.22. Individual thermoluminescent dosimeter results and locations are provided

Table 3.2.20. Activities of Selected Radionuclides in 200/600 Areas Vegetation, 1998 (pCi/g)

	^{60}Co	^{90}Sr	^{137}Cs	^{234}U	^{235}U	^{238}U	^{239,240}Pu
Sampling locations[a]		Site V058	Site V034	Site V002	Site V104	Site V022	Site V008
Maximum[b]	ND[c]	1.2 ± 0.2	0.49 ± 0.08	0.042 ± 0.011	0.021 ± 0.008	0.021 ± 0.007	0.061 ± 0.014
Average[d]	ND	0.33 ± 0.13	0.21 ± 0.09	0.016 ± 0.003	0.0086 ± 0.0016	0.0097 ± 0.0013	0.018 ± 0.008
Offsite averages[d,e]	NR[f]	0.025 ± 0.012	0.0072 ± 0.0083	0.014 ± 0.006	ND	0.013 ± 0.004	0.00018 ± 0.00013

(a) See PNNL-12088, APP. 2.
(b) ± counting error.
(c) ND = Not detected.
(d) ±2 standard error of the mean.
(e) PNNL-10574 and PNNL-11795.
(f) NR = Not reported.

Table 3.2.21. Activities of Selected Radionuclides in 300/400 Areas Vegetation, 1998 (pCi/g)

	^{60}Co	^{90}Sr	^{137}Cs	^{234}U	^{235}U	^{238}U	^{239,240}Pu
Sampling locations[a]		Site V130		Site V119	Site V117	Site V119	Site V118
Maximum[b]	ND[c]	0.10 ± 0.06[d]	ND	0.28 ± 0.05	0.0.17 ± 0.009	0.28 ± 0.05	0.0084 ± 0.0045[d]
-							
Average[e]	ND	--	ND	0.046 ± 0.033	0.0092 ± 0.0028	0.044 ± 0.036	--
Offsite averages[e,f]	NR[g]	0.025 ± 0.012	0.0072 ± 0.0083	0.014 ± 0.006	ND	0.013 ± 0.004	0.00018 ± 0.00013

(a) See PNNL-12088, APP. 2.
(b) ± counting error.
(c) ND = Not detected.
(d) Single value above detection limits.
(e) ±2 standard error of the mean.
(f) PNNL-10574 and PNNL-11795.
(g) NR = Not reported.

in PNNL-12088, APP. 2. Specific information regarding external radiation sampling methods and locations can be found in WMNW-CM-004.

The environmental thermoluminescent dosimeters measure dose rates from all types of external radiation sources. These include cosmic radiation, naturally occurring radioactivity in air and soil, and fallout from nuclear weapons testing, as well as any contribution from Hanford Site activities. These outside radiation sources cause an estimated 20% deviation in results from the thermoluminescent dosimeter analyses. The results are reported in units of millirems per year.

Near-facility monitoring uses the Harshaw thermoluminescent dosimeter system, which includes the Harshaw 8807 dosimeter and the Harshaw 8800 reader. The reader has a better signal-to-noise ratio than those used in the past. The packaging, which uses an O-ring seal, protects the dosimeter from light, heat, moisture, and dirt. The thermoluminescent

Table 3.2.22. Thermoluminescent Dosimeter Results for Waste Handling Facilities, 1997 and 1998, mrem/yr based on 24 h/d

Area	No. of Locations, 1998	1997 Maximum	1997 Mean	1998 Maximum	1998 Mean	% Change[a]
100-B	4	96	93	110	97	4
100-D	5	93	88	125	96	9
100-K	11	2,250	470	720	180	-61
100-N	18	7,700	1,300	7,000	1,600	22
200/600	63	350	110	320	100	-5
TWRS[b]	10	81	78	88	86	10
ERDF[c]	3	100	95	100	95	0
300	8	200	110	210	110	0
300 TEDF[d]	6	87	82	89	83	1
400	7	88	86	87	84	-2

(a) Numbers indicate a decrease (-) or increase from the 1997 mean.
(b) TWRS = Tank Waste Remediation System Phase I demonstration project.
(c) ERDF = Environmental Restoration Disposal Facility.
(d) TEDF = 300 Area Treated Effluent Disposal Facility.

dosimeters were placed 1 m (3.3 ft) above the ground near facilities, active and inactive surface-water disposal sites, and remedial action projects. The dosimeters were exchanged and analyzed each calendar quarter. The Pacific Northwest National Laboratory's Radiological Calibrations Facility in the 318 Building (300 Area) calibrates the response of the chips; results are reported in terms of external dose.

To evaluate environmental restoration activities at the former 116-B-11 and 116-C-1 Liquid Waste Disposal Facilities, four new thermoluminescent dosimeter monitoring sites were established during the fourth quarter of 1997. Dose rates measured at these locations were elevated 4% compared to the extrapolated data from 27 d of data collection during the fourth quarter of 1997. The 1998 average dose rate was 97 mrem/yr, which is comparable to offsite ambient background levels.

In the 100-D,DR Area, this is the third year that thermoluminescent dosimeters have been placed to evaluate cleanup activities at the former 116-D-7 and 116-DR-9 Liquid Waste Disposal Facilities. Dose rates measured at these locations were 9% higher than the results of 1997, with an average dose of 96 mrem/yr, which is comparable to offsite ambient background levels.

The cleanup activities at the K Basins and adjacent retired reactor buildings in the 100-K Area continue to be monitored. Dose rates in this area decreased 61%, with an average of 180 mrem/yr, because of the removal of radioactive waste stored in proximity to the three thermoluminescent dosimeter locations.

The 1998 results for the 100-N Area indicate that direct radiation levels are highest near facilities that had contained or received liquid effluent from N Reactor. These facilities primarily include the retired 1301-N and 1325-N Liquid Waste Disposal Facilities. While the results for these two facilities were noticeably higher than those for other 100-N Area thermoluminescent dosimeter locations, they were approximately 17% lower than dose levels measured at these locations in 1997. Overall, the average

dose rate measured in the 100-N Area in 1998 was approximately 22% higher than that measured in 1997 because of the removal of eight dosimeters in low-background areas.

Dose rates were measured at the N Springs shoreline to determine potential external radiation doses to the public as well as to onsite workers. Because of the "skyshine" effect (i.e., radiation reflected by the atmosphere back to the earth's surface) from the retired 1301-N facility, dose rates at the N Springs shoreline were elevated (>100 mrem/yr), which is the DOE annual external dose limit to members of the public. However, neither a member of the public nor a Hanford worker would conceivably spend an entire year at the N Springs; therefore, the values shown in Figure 3.2.4 are for comparison only. N Springs dose reduction measures are being studied.

Annual average thermoluminescent dosimeter results at 100-N Area from 1987 through 1998 are presented in Figure 3.2.5.

The highest dose rates in the 200/600 Areas were measured near waste handling facilities such as tank farms in the 200 Areas. The location within the 200/600 Areas exhibiting the highest dose rate was at the A Tank Farm in the 200-East Area. The average annual dose rate measured in the 200/600 Areas in 1998 (104 mrem/yr) was 5% lower than the average 1997 measurement. The annual average thermoluminescent dosimeter results from 1987 through 1998 are presented in Figure 3.2.6.

Ten new thermoluminescent dosimeter locations were established around the perimeter of the Tank Waste Remediation System Phase I demonstration project site during the fourth quarter of 1997 to collect preoperational monitoring data. Dose rates measured at these locations in 1998 were comparable to the results of 1997, with an average of 86 mrem/yr. This is comparable to offsite ambient background levels.

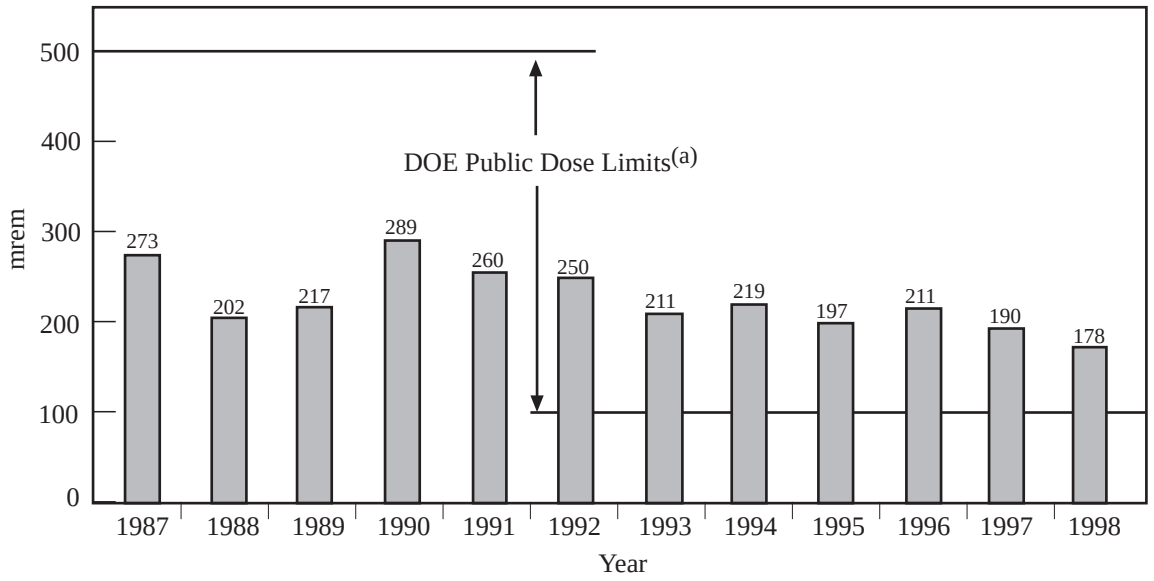


Figure 3.2.4. Average Annual Dose Rate at N Springs. (a) DOE limits were reduced from 500 mrem/yr in 1992. The lower value was selected in recognition of the International Commission of Radiation Protection recommendation to limit the long-term average effective dose equivalence to 100 mrem (1 mSv)/yr or less (DOE Order 5400.5)

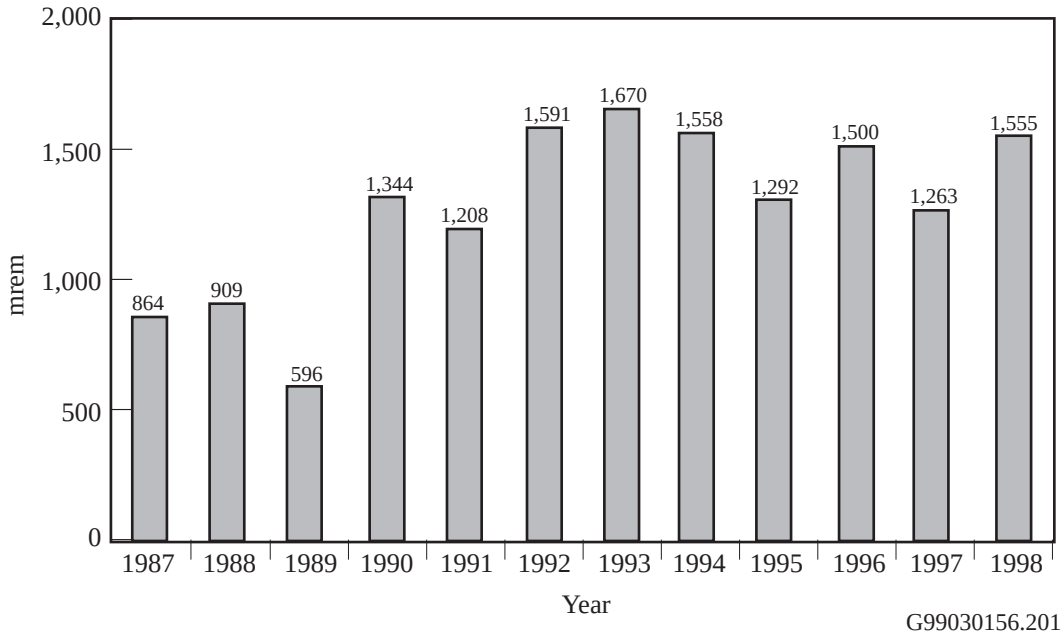


Figure 3.2.5. Annual Average Thermoluminescent Dosimeter Results in the 100-N Area

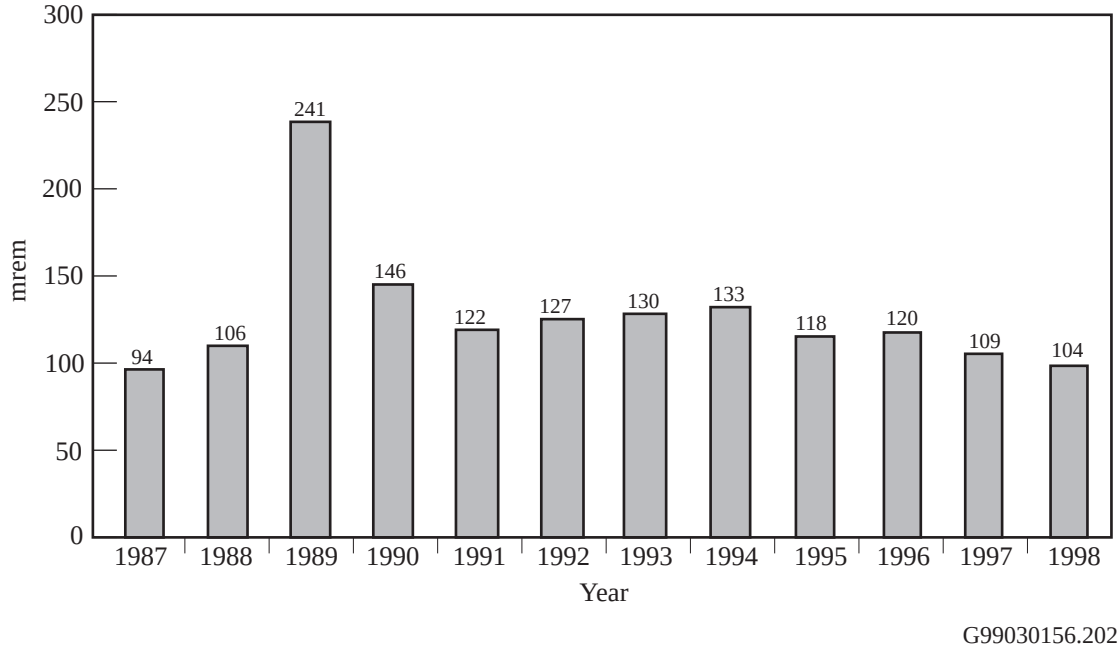


Figure 3.2.6. Annual Average Thermoluminescent Dosimeter Results in the 200/600 Areas

This is the second year that thermoluminescent dosimeters have been placed at the Environmental Restoration Disposal Facility to evaluate ongoing activities. Dose rates measured in 1998 were slightly lower than the 1997 results, with an average of 92 mrem/yr, which is comparable to offsite ambient background levels.

The highest dose rates in the 300 Area in 1998 were measured near the 340 Waste Handling Facility. The average dose rate measured in the 300 Area in 1998 was 110 mrem/yr, which is equal to the average dose rate measured in 1997. The average dose rate at the 300 Area Treated Effluent Disposal Facility in 1998 was 82 mrem/yr, which is a 1% increase compared to the average dose rate measured in 1997. The average dose rate measured in the 400 Area in 1998 was 84 mrem/yr, which is a 2% decrease to the average dose of 86 mrem/yr measured in 1997. The annual average thermoluminescent dosimeter results from 1991 through 1998 are presented in Figure 3.2.7.

3.2.6 Investigative Sampling

Investigative sampling was conducted in the operations areas to confirm the absence or presence of radioactive and/or hazardous contaminants where known or suspected radioactive contamination was present or to verify radiological conditions at specific project sites. Investigative sampling took place near facilities such as storage and disposal sites for at least one of the following reasons:

- to follow up radiological surface surveys that had indicated radioactive contamination was present
- to conduct preoperational surveys to characterize the radiological/chemical conditions at a site before facility construction, operation, or ultimate remediation

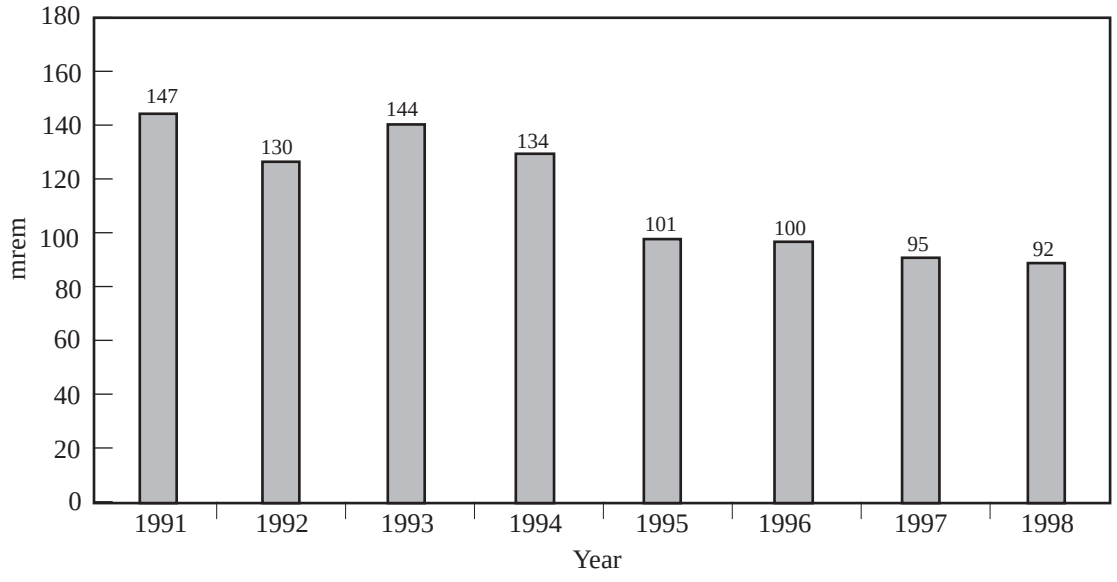


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Figure 3.2.7. Annual Average Thermoluminescent Dosimeter Results in the 300/400 Areas and at the 300 Area Treated Effluent Disposal Facility

- to determine if biotic intrusion (e.g., animal burrows or deep-rooted vegetation) has created a potential for contaminants to spread
- to determine the integrity of waste containment systems.

Generally, the predominant radionuclides discovered during these efforts were activation and fission products in the 100 and 200 Areas and uranium in the 300 Area. Hazardous chemicals generally have not been identified above background levels in preoperational environmental monitoring samples.

Investigative samples collected in 1998 included vegetation (tumbleweeds), nests (bird, wasp, ant), mammal feces (rabbit), mammals (mice, bat), and insects (fruit flies).

Methods for collecting or otherwise obtaining investigative samples are described in WMNW-CM-004. Field monitoring was conducted to detect radioactivity in samples before they were submitted for analysis. Field monitoring results are expressed as disintegrations per minute when a Geiger-Müeller detector is used or as millirad per hour when an ion chamber is used. To obtain the field instrument readings, measured background radioactivity was subtracted from the Geiger-Müeller readings (in counts per minute) and converted to disintegrations per minute per 100 cm^2. Laboratory sample analysis results are expressed in picocuries per gram, except for extremely small samples. Small samples are expressed in picocuries per sample. Maximum activities, rather than averages, are presented in this section.

In 1998, 51 investigative samples were analyzed for radionuclides at the 222-S Laboratory in the 200-West Area. Of the samples analyzed, 50 showed measurable levels of activity. Analytical results are provided in PNNL-12088, APP. 2. Another 133 contaminated investigative environmental samples were reported and disposed of without isotopic analyses (though field instrument readings were recorded) during cleanup operations. These results are also provided in PNNL-12088, APP. 2. Only radionuclide activities above analytical detection limits are provided in this section.

In 1998, there were 41 instances of radiological contamination in investigative soil samples. Of the 41, 18 were identified only as "speck" contamination. Seven investigative samples were collected for radioisotopic analysis, and 33 contaminated soils or specks were found during cleanup operations and disposed of in low-level burial grounds without analysis. External radioactivity levels ranged from slightly above background (approximately 9,250 dpm/100 cm^2) to >1,000,000 dpm/100 cm^2. The contaminated areas were radiologically posted or cleaned up.

The number of investigative soil contamination incidents, range of radiation dose levels, and radionuclide activities in 1998 were generally within historical values. Areas of special soil sampling that were outside radiological control areas and had levels greater than radiological control limits were posted as surface contamination areas.

In 1998, there were 51 instances of radiological contamination in investigative vegetation samples. Of the 51, 47 were identified as tumbleweed, 1 as sagebrush/rabbitbrush, and 3 as vegetation. Nine tumbleweed samples and the sagebrush/rabbitbrush sample were analyzed for radionuclide activities. Three of those samples showed field readings in excess of 1,000,000 dpm/100 cm^2. Of the three tumbleweed samples with the highest field readings, two were wind blown weeds collected from the 200-East Area fence and the third was collected from the diversion box on the transfer line between the 200-East and 200-West Areas. Analysis of contaminated tumbleweeds showed strontium-90 levels as high as 7,360,000 pCi/g and cesium-137 levels as high as 1,410,000 pCi/g.

Investigative vegetation samples not sent to the laboratory for analysis were disposed of in low-level burial grounds. The number of contaminated investigative vegetation incidents in 1998 (51) was

comparable to those observed in 1997 (46). The radioactivity levels and range of radionuclide activities were all within historical levels (WHC-MR-0418).

Investigative wildlife samples were collected directly from or near facilities to monitor and track the effectiveness of measures designed to deter animal intrusion. Wildlife is collected either as part of an integrated pest management program, designed to limit the exposure to and potential contamination of animals with radioactive material, or as a result of finding radiologically contaminated wildlife-related material (e.g., feces, nests) during a radiation survey.

Surveys were performed after collection of wildlife to determine whether an animal was radioactively contaminated. If a live animal was found to be free of contamination, it was taken to an area of suitable habitat, still in a controlled area, and released. If an animal was contaminated, a decision was made based on the level of contamination, location, and frequency of occurrence either to collect the animal as a sample or to dispose of the animal in a low-level burial ground.

In 1998, 34 wildlife and wildlife-related samples were submitted for analysis. This compares to 22 samples collected in 1997, 37 in 1996, 22 in 1995, and 16 in 1994. The number of samples submitted for analysis depended on opportunity (i.e., resulting from the pest control activities at facilities) rather than prescheduled sampling at established sampling points. Fifteen fruit flies were gathered as a result of a newly identified pathway of contamination.

All 34 wildlife-related samples showed detectable levels of contamination, except for a sample of crystalline material thought to be associated with contaminated fruit flies. One sample, composed of six mice, showed very low detectable levels of strontium-90 (0.3 pCi/g) and uranium (0.0032 pCi/g).

The maximum radionuclide activities in 1998 were in mouse feces collected near the 241-ER-151 Diversion Box south of B Plant in the 200-East Area. Contaminants included strontium-90 (450,000 pCi/g), cesium-137 (460,000 pCi/g), europium-154 (560 pCi/g), plutonium-238 (45 pCi/g), plutonium-239,240 (170 pCi/g), and total uranium (2.0 pCi/g). The numbers of animals found to be contaminated with radioactivity, their radioactivity levels, and the range of radionuclide activities were within historical levels (WHC-MR-0418).

There were 21 cases of contaminated wildlife or related samples found during cleanup operations that were not analyzed. These samples included anthills, mouse feces, coyote urine, rabbit feces, mice, fruit flies, and a beetle. The field instrument readings for the unanalyzed samples ranged from approximately 1,000 to >10,000,000 dpm/100 cm^2.

Special characterization projects conducted or completed in 1998 to verify the radiological, and in some cases, potential hazardous chemical status of operations included those listed below.

- A preoperational environmental survey was initiated for the Project W-314 pipeline, which is to be constructed in the 200-East Area for the Tank Waste Remediation System Project to provide needed upgrades for waste transfer control and instrumentation for existing tank farm facilities. A sample and analysis plan (HNF-3594) was prepared and issued.
- A preoperational environmental survey is planned in support of the Spent Nuclear Fuels Project Facilities during 1999 and 2000. The surveys will concentrate on areas near the Cold Vacuum Drying Facility in the 100-K Area and the Canister Storage Building and Interim Storage Area in the 200-East Area.